U. S. DEPARTMENT OF AGRICULTURE,

WEATHER BUREAU.

THE

Mild Temperature of the Pacific Northwest

AND THE

Influence of the "Kuro Siwo,"

BY

B. S. PAGUE, A. M., LL. B.,
Forecast Official, U. S. Weather Bureau.

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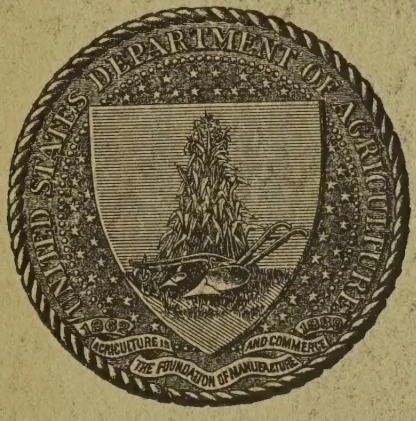

PORTLAND, ORE.,
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PREFACE.

The Chief of the Weather Bureau solicited papers, from all weather bureau officials, for publication in his annual report, and in response I prepared the paper printed upon the following pages. The paper was forwarded to Washington city on September 30, 1899, and was referred by the Chief of Bureau to the usual committee for examination. The report of this committee is also printed. It is the hope of the writer that the truth of his theory may be fully established, or that it may be shown to be erroneous. There are many fallacies existing, and, believing the gulf-stream theories, as now understood, to belong to that class, the writer endeavors to prove his statement.

Another paper on this subject will probably be prepared during the coming year. Data will then be furnished to show that although the ocean is a great modifier of the temperature of the air over the Pacific Northwest, yet the Japan Gulf current has no influence upon it, and the modifying influence which has heretofore been attributed to this current is due to dynamic heating. The following thesis, therefore, though expressing the personal views of the writer, should be considered as a preliminary exposition of the subject.

B. S. PAGUE, A. M. LL. B.
Forecast Official.

U. S. Weather Bureau Office, Portland, Oregon, November 1, 1899.

The following is the report of the committee above referred to:

9163: W. B. 1899.

U. S. DEPARTMENT OF AGRICULTURE.
WEATHER BUREAU.

Office of Editor of Review.
WASHINGTON, D. C., October 17, 1899.

Chief of Bureau:—

In response to your request, we have the honor to report as follows on the paper submitted by Mr. Pague (No. 9163), "The Mild Temperature of the Pacific Northwest and the Influence of the Kuro Siwo."

This paper was received too late to be published in your current Annual Report, we therefore recommend that Mr. Pague be allowed to publish it in any convenient way.

The opening paragraph attributes to meteorologists an opinion that, we believe, has never prevailed among them to any great extent, but it is frequently maintained in the daily newspapers.

We do not find any satisfactory proof that the influence of the ocean is not sufficient to account for the difference between the climate of our Northwest coast and that of other points on the same latitude. We recognize that when air descends the mountain or Pacific slope, it must be warmed by compression, and the cases quoted by Mr. Pague may illustrate actual occurrences of this kind, but he gives no data to show that these occur often enough to become an important feature of that climate.

This paper has an interest as illustrating the views of one of our most successful forecast officials, but we must consider the importance which he attaches to dynamic heating rather as a hypothesis than as a principle satisfactorily demonstrated in the present essay. The views presented by him are worthy of study, and if the author would allow of the publication of some considerable extracts from this paper in the Monthly Weather Review, we think that your object in ordering such papers prepared for the Annual Report would be partly attained.

Very respectfully,

CLEVELAND ABBE,
Professor and Editor.

A. J. HENRY,
Chief of Division.

Approved: Forwarded to Mr. Pague.
WILLIS L. MOORE, Chief of Bureau.

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Meteorologists have given credit to the "Kuro Siwo," the Japan gulf current, for the mildness of the winter temperature prevailing over the Pacific Northwest—Oregon, Washington and Idaho. Similar credit has been given to the Mexican gulf stream for its influence upon the temperature of the British isles and Northwestern Europe. Precedent and accepted theories are always hard to combat, and, when an idea has long been accepted as true, to controvert it is indeed difficult. There is no science susceptible of more development, nor is there a science which will yield more valuable results than the science of meteorology. Desultory efforts have been made for hundreds of years to determine facts in relation to the causes which produce the varying weather conditions, but without avail From these various efforts, general rules or laws have been deduced, which more recent investigations fail to verify. As is said by Professor Cleveland Abbe:

"We may experiment upon small quantities of air and aqueous vapor in the physical laboratory, and thus learn some of the details as to the physical properties of the atmosphere; but the meteorological phenomena on a large scale can only be studied by means of formulae, or equivalent graphic methods peculiar to hydrodynamics and thermodynamics. It is evident, therefore, that important progress in meteorology is not to be hoped for from those who only frame hypotheses and speculations as to possible laws that may control atmospheric phenomena.

"Such hypotheses are often important; it is well said that even the clear statement of a difficulty, or of a problem, is already a long step toward its solution. But the solution is the final step that meteorology demands, and the one that is absolutely essential in order that we may really make true progress. Meteorology presents many unsolved problems, and many more will be recognized as time goes on."

It has been left to the closing years of the 19th century to make the most thorough investigations in the science of the weather; to prove some well-defined and previously announced laws, and to disprove others. There is, perhaps, no more difficult thing to do than to disprove that which for years has been accepted as true, but it is the purpose of this paper to endeavor to do so.

The Pacific Northwest lies west of the Rocky mountains, and between the 42d and 49th degrees, north latitude. This is the latitude of the Great Lakes, of Southern Canada, and of Northern Central Eu-

rope. The rigorous winter climate of these latter regions is well known, as is also the mild winter climate of the Pacific Northwest. The mildness of this climate attracted the attention of meteorologists, and an explanation of the causes producing it was sought. That which is most apparent, or that which superficially appears to be the most probable, is often accepted as the cause, and this is especially true concerning meteorological problems which, at their best, are generally mere theories, and in this instance, the influence of the ocean and more especially that of the Japan gulf current, the "Kuro Siwo," has been given the credit for the mildness of the winter temperatures prevailing over this region.

That this has not only been accepted upon insufficient grounds, but that it is erroneous, it is the purpose of this paper to demonstrate, and, furthermore, an argument based upon reliable data is here given, to show what is the real cause of the mild climate of the Pacific Northwest, and, by analogy, that of the western and northwestern parts of Europe.

The Japan Current.

The "Kuro Siwo" has its origin in the sea of Japan. It moves in a northerly direction along the coast until it reaches Kamchatka, where it divides, one portion flowing northward into the Arctic ocean, the other flowing eastward along the Alaska coast, thence southward along the British Columbia, Washington and Oregon coasts, until it finally becomes unrecognizable off the California coast. It is true that this stream of water retains a well-marked path for many thousand miles, and that off the China coast its temperature is much higher than that of the surrounding ocean water; but, as it advances northward, thence eastward and southward, it rapidly loses its marked difference in temperature, until off the coast of the Pacific Northwest its temperature is only about 2 deg. higher than that of the surrounding water.

Now, if the width of this stream be considered but for a moment in its relation to the great body of water composing the Pacific ocean, it must surely be conceded that it is entirely too small to be a factor in influencing the temperature of the air resting on or passing over it. A laboratory experiment would have to be very carefully conducted and with the most delicate instruments, if the effect of a very minute stream of water, having but a slightly higher temperature than that of a large body of water surrounding it, were to be detected. If the air were confined; if there were no ascending or descending currents; if this additional heat could be conserved, then, possibly, an appreciable effect might be shown; but, as it is, the influence is felt to be so little that it becomes difficult to understand how so much weight could ever have been attached to so small a factor. Let us then, in the search for truth, emancipate ourselves from the undue influence of this old Japan gulf theory and approach with unbiased mind the consideration of the causes of the modified climate of the Pacific Northwest.

It is an accepted and well-established law, that bodies of water have a materially modifying effect upon the temperature of the surrounding region. This effect is observable along the banks of a stream, a river or lake, and is best marked along the shores of the ocean.

At Cleveland, O., the temperature during the prevalence of midwinter's cold, is several degrees higher than at places 50 miles south. This is caused by the influence of Lake Erie. The greater amount of moisture contained in the air, over and surrounding the lake, acts as a covering and protects the earth, not only by diminishing largely the influence of the external cold, but also by retarding radiation of heat from the earth itself.

On a still larger scale is the influence of the ocean, and far more marked are its effects. The winds from the ocean blowing on to the Pacific Northwest pass over thousands of miles of water, and the surface winds attain the temperature of the water of the ocean; these winds in the

summer season modify the summer heat and in winter produce a higher temperature than in this latitude would otherwise be the case. These effects are the result of the great body of water and its temperature and not the effect of the minute portion of the ocean called the "Kuro Siwo."

The modifying effect of the ocean upon the climate of the Pacific Northwest is best illustrated by a comparison of the temperature on the east side of the Cascade mountains with that on the west side. The mountains are a partial barrier to the ocean's influence, hence in winter the temperature east of the mountains more nearly attains that degree of cold to be expected in a country with such high latitude than is found west of them. The influence of the ocean is, however, marked on the temperature east of the Cascades, and its influence really extends to the summit of the Rocky mountains and beyond; this is shown by the isothermal lines.

At Portland, during 1897, the mean temperature was 53 degrees; in January the mean was 39 degrees; in August 71 degrees. At Walla Walla, nearly in the center of the country between the Cascades and Rocky mountains, the mean for the year was also 53 degrees; in January the mean was 31 degrees, in August 71 degrees. On the other hand, at Fort Canby, on the ocean edge, the mean for the year was 50 degrees, but 3 degrees less than that of Portland and of Walla Walla, but in January the mean was as high as 42 degrees, whereas, in August, it was but 60 degrees. These three places furnish an excellent illustration of the ocean's influence.

In January, on the shore of the ocean, the mean temperature in 1897 was 42 degrees; at Portland, midway between the coast and the Cascade range, the mean was 39 degrees, and at Walla Walla it was 31 degrees, making clear the point that, the farther removed from the ocean, the less the difference in temperature from what would naturally be expected in so high a latitude.

This is shown in the August temperature as well. Remove the ocean's influence and the temperatures would more nearly resemble those found at Bismarck, N. D. This, then, is the ocean's influence, independent of the "Kuro Siwo," i. e.: higher winter and lower summer temperatures. The oceanic influence, however, is not sufficient to account for the fact that there is a range in the mean annual temperature at Fort Canby of 19 degrees.

Admitting, then, that the "Kuro Siwo" has no material effect upon the temperature of the Pacific Northwest, and that the reason for the higher temperature there than in places east of the Rocky mountains in the same latitude is not sufficiently accounted for by the influence of the ocean itself, why, then, do abnormally high temperatures prevail in the winter season, and why is the mean temperature higher than the direct influence of the ocean causes it to be? The answer is, as understood by the writer, dynamic heating.

Expansion of air produces cooling, while compression produces warming. To follow the reasoning of this subject, the movement of high and low barometric areas over the Pacific Northwest, as well as the geography of the country, must be understood.

Geography.

Parallel with the coast line is the Coast range of mountains, having an elevation of from 1000 to 3000 feet; east of this, varying in distance from 60 to 120 miles, is the Cascade range, having an elevation of from 2000 to 5000 feet, with several peaks exceeding 10,000 feet. East of the Cascades, and for a distance of from 500 to 900 miles from them, there are plateaus, valleys and mountain ranges extending to the Rocky mountains. These plateaus have elevations ranging from 2000 to 5000 feet; the valleys have elevations of from 400 to 3000 feet, and the Rocky mountains, in the Pacific Northwest, vary in height from 4000 to 8000 feet. The summit of the Rocky mountains is considered the East-

ern line of the Pacific Northwest. The Columbia and tributary rivers drain the country under discussion, and the valley of the Columbia is generally less than 1000 feet in elevation.

Atmospheric Movement.

Areas of high barometric pressure, affecting the Pacific Northwest come from two directions; from the north of Montana and from the California coast. The former rarely occurs except during the winter months, the latter in summer and winter. If in summer, it moves northward to the Washington coast and to Vancouver's island and thence eastward; if in winter, it moves northward to the Central Oregon coast, occasionally as far north as the Columbia river, and thence in a southeasterly direction to Southern Idaho.

Areas of low barometric pressure have three movements over the Pacific Northwest, two major movements and one minor. Of the major, the principal is the winter movement. This comes from the north, along the coast, becoming central over Northwestern Washington or over Vancouver's island, thence moving eastward, being occasionally deflected southward temporarily to the Columbia river; thence it returns northward and then eastward. In rarer cases the "low" moves southward over Western Oregon and over California, following closely the course of the Sierra Nevada mountains to Southern Nevada or Northern Arizona, thence eastward. This latter movement is rare and is always followed by severe weather.

The second movement of the major class is peculiar to the summer season. In this case, the "lows" move southward from the Arctic region, on the East side of the Rocky mountains, to Montana. Occasionally they develop a western trough, influencing the weather over the Pacific Northwest, but, more generally, they move southeastward toward the Great Lakes.

The third, or minor class, is confined exclusively to the summer season. It develops over Northern California and moves northeastward to Oregon and Southern Idaho. Such "lows" produce thunder storms and, occasionally, they unite with a "low" from the north which has developed a southwestern trough, and then general rain over the Pacific Northwest results. There are minor modifications of these "highs" and "lows," but those that have been described are the parents of all others, and sufficient mention has been made of them for the purpose of this paper.

Dynamic Heating.

The winter "highs" travel from the California coast northward to the central Oregon coast and thence move slightly south of east, becoming central over Southern Idaho and the adjacent country. This country has an elevation ranging from 4000 to 7000 feet, and upon this semi-plateau is a high barometric area, almost constant from November to March. It is varying in its weight, dependent upon the movement of the "lows" on the north and the reinforcement by "highs" from the ocean. Coincident with the movement of a "high" from the ocean, there is, almost always, a "low" from the north, becoming central about Northwestern Washington, while the "high" is becoming central over the plateau region. The "low" becomes well defined in its position within 24 hours after the "high" has become well defined in its position. The "low" then begins its eastern movement.

The elevation of the land over which the "low" passes, and over which it has its influence, is much less than the elevation of the land where the high is located. In addition the "high," with its pressure of 30.5 inches and more, extends above the earth's surface fully 1000 feet higher than the top of the "low," with its pressure of about 29.5 inches, so that the "high," in flowing into the "low," not only descends from its elevated plateau, but 1000 feet in addition, causing a gradient from the "high" to the "low" of a maximum amount of about 7000 feet.

In this flow of the air, from the high to the low elevation, compression naturally occurs and dynamic heating results. There is almost a permanent "low" over Northwestern Washington and Southwestern British Columbia, from November to March, and, during the same time, there is almost a permanent "high" over the plateau region of Southern Idaho. The dynamic effects prevail with increased or decreased intensity, as the "high" and "low" increase or decrease, but the effect is observable in a greater or less degree almost continuously throughout the winter season, from November to March.

It is due to this cause more than the influence of the ocean, or the "Kuro Siwo," that the winter's temperature over the Pacific Northwest is as mild as it is. It is not denied that the ocean has a great influence, but the assertion is made that the "Kuro Siwo" has practically no effect, and that the dynamic heating is greater in its effect than even the influence of the ocean itself.

During the winter season the temperature over the Pacific Northwest is influenced by various causes. When the "highs" move from the ocean to the central Oregon coast, thence to the plateau region of southern Idaho, the temperature over the greater portion of the Pacific Northwest is directly influenced thereby, and the temperature may then be considered the effect of purely oceanic influence. The temperature of these "highs" is, in January, about 44 degrees along the coast; about 38 degrees between the coast and Cascade ranges, and about 26 degrees east of the Cascades over the Eastern Oregon plateau; or, in other words, the temperature of these "highs" decreases from 44 degrees to 26 degrees, while the "highs" are moving inland about 300 miles, crossing two mountain ranges and rising from sea level to a plateau having an elevation of 3300 feet, which is equivalent to a decrease of 1 degree in temperature for about every 183 feet of ascent, a loss of heat about equal to the normal adiabatic rate. The "highs" continue their eastern movement and become central on the higher elevations of Southern Idaho, in which movement still more heat is lost, so that when the "high" is stationary, the temperature of the air in the center of the high is about five to ten degrees above zero, a total decrease of about 34 to 39 degrees.

Expansion and Compression.

Dr. Frank Waldo, in the chapter of his excellent "Modern Meteorology," devoted to the thermo-dynamics of the atmosphere, discusses the effect of the movement of "highs" when ascending, and their effect when descending elevations. Dr. Waldo uses figures for illustration which it is not practical to reproduce here, but their careful study is commended to the readers of this paper.

In the present writer's pamphlet on "Weather Forecasting," Weather Bureau print, Portland, Oregon, 1897, appears the following statement, based upon the theory as stated by Dr. Waldo, concerning the movements of "highs" up and down mountain sides.

"Moist air expands during its rise up the side of the mountain, and is then again compressed in its descent without having any heat added or withdrawn. Furthermore, if the expansion and subsequent compression takes place without the precipitation of moisture, the air will reach the same level on the leeward side of the mountain, at the same temperature it had at the corresponding level on the windward side. When precipitation has occurred, the air will reach the summit of the mountain at a higher temperature than the theoretical rate of decrease which elevation would assign to it, and in this changed condition the initial temperature will be reached at a pressure much lower than the initial pressure. Continuing in the descent, the original level will be reached with a higher temperature than at the starting point, and the air will be much drier, and these conditions will be more marked in proportion as the original mass of air is warm and moist or cold and dry."

The "high" usually precipitates moisture, in its movement from the ocean to the plateau region. Almost coincident with the high's becoming central over the plateau region, an area of low pressure appears and becomes central about Vancouver's island. A movement of the atmosphere from the "high" to the "low" at once commences. Previous to the commencement of the movement of the winds from the "high" to the "low," the temperature of the air is, beyond a doubt, that which has been produced by the influence of the ocean; as soon as the movement to the "low" commences, a rise in the temperature is observable. Precipitation having occurred during the ascent of the air, in its descent the air will reach its initial level with more than its initial temperature, and also much drier than it was at first. Recorded data prove this to be the case.

Areas of high pressure have the movement just described at intervals of seldom over 10 days, and the influences last for from three to five days, so that from nine to 15 days of almost every month, from November to April, the temperature of the Pacific Northwest is under the influence of dynamic heating, the heat then produced being much greater than that resulting from the ocean's influence. Thus it is seen how the dynamic effects are more responsible for the mild temperature than is the "Kuro Siwo," or the ocean itself.

Abnormal Temperature.

Temperatures below the normal over the Pacific Northwest occur from two causes, and, when the causes are combined extreme cold weather prevails. The causes are:

1. The movement of a barometric depression from Idaho southward toward Arizona.

2. The presence of a barometric depression off the Oregon coast and the movement of an area of high pressure southward from Alberta.

In the first case the depression may be great or small, and, dependent upon the size of the depression, is the degree of coldness. Its duration is dependent upon the movement, or the filling up of the depression. The first cause is, as a rule, peculiar to the summer season.

In the second case the "high" moves south and overflows to the westward, producing cold north to east winds and generally snow. Such movements occur almost every year, but the severity of the cold is variable. This movement is confined entirely to the winter season. In both these cases, continental conditions prevail and control the temperature.

The conditions which produce the warm weather have now been described, as have been also those which produce the cold weather and those which prevail at other times. From these the reader is enabled to draw his own conclusions.

During February, 1899, one of the coldest periods on record prevailed over the Pacific Northwest. A brief description of the conditions precedent to and during that cold period and the warm period which followed may assist in making clearer the idea sought to be developed in this paper. The mean temperatures at Portland and at Walla Walla during a portion of February, 1899, will assist in doing this:

Mean Temperature.

Date.	Portland.	Walla Walla.
February, 1899.	Deg.	Deg.
1	28	25
2	18	8
3	17	5
4	15	6
5	20	2
6	22	6
7	32	12
8	44	18
9	46	23
10	42	38
11	38	20
12	44	28
13	50	40
14	50	48
15	48	46
16	46	44
17	48	52
18	54	52
19	50	51
20	44	42

It will be observed that the temperature fell from the 1st to the 4th of February at Portland and from the 1st to the 5th at Walla Walla, after which there was a steady rise in the temperature to the 13th and 14th. From the 15th to the end of the month, the mean temperature ranged from 41 deg. to 54 deg at Portland, and from 28 deg. to 52 deg. at Walla Walla. The barometric conditions were, on the 1st, an area of high pressure (30.74) central over Alberta and a "low" (29.48) central at Fort Canby.

From 8 A. M. of the 1st to 8 A. M. of the 2d, the "low" moved over the southern portion of Oregon and was central on the latter date over Northern Nevada; the "high" filled up the depression over Washington and Oregon, but it continued central over Alberta, where the reading was 30.50. On the 3d the "low" was central over Utah, the "high" increased over Alberta to 30.76, and the pressure rose over Washington and over Oregon.

By the morning of the 4th the "low" had disappeared and the "high" (30.64) moved southward to Helena; the morning of the 5th, the "high" (30.74) was central at Idaho Falls, and the pressure was 30.20 at Fort Canby. The "high" then began filling the relatively "low" depression west of the Cascades and at the same time increasing its own energy. On the 6th the barometer reading at Idaho Falls was 30.84 and at Fort Canby 30.46.

Rise of Temperature.

It will now be observed, by reference to the temperature data above that on the 4th, when the "low" disappeared, the temperature began to rise at Portland. On the 5th a rise at Walla Walla also occurred. The movement of the "high" from the elevated plateau to the lower levels on the west and north, is shown in the rise in temperature from the 5th and 6th. On the 7th the high (30.84) continued about Idaho Falls, and the relative "low" (30.22) continued at Fort Canby. On the 8th the main body of the "high" (30.64), moved to Bismarck; the barometer continued high (30.56) at Idaho Falls, and fell to 30.18 at Fort Canby. On the 9th the barometer was 30.02 at Fort Canby and 30.50 at Idaho Falls. Dynamic heating was well marked on the 9th, and is shown by the foregoing table. The "high" at Idaho Falls lost energy on the 10th, and the relative "low" at Fort Canby was filled by a "high" from the north. An area of high presure (30.38) was off the California coast on the 9th, and this "high" checked the western overflow of the "high" (30.28) central north of Montana on the 11th.

Without further description of the "highs" and "lows" during the month, for the above is thought to be sufficient to show that the temperature is directly dependent upon the relative position of them, the net result of the effects will illustrate the subject more clearly. Considering that the temperatures of the Pacific Northwest can be divided into classes, and those classes called:

CONTINENTAL
DYNAMIC } TEMPERATURE,
OCEANIC

it is then proper to classify the causes producing each class in the following manner:

Continental temperatures occur when the barometer is higher over Alberta than along the Washington coast.

Oceanic, when the barometer is higher at any place from Cape Mendocino to Vancouver's island than it is east of the Cascades, or when an area of high pressure is moving over Oregon to Idaho.

Dynamic, when the barometer is higher over Southern Idaho than it is along the Washington coast.

Having these definitions, the following is shown by the February (1899) data of Portland:

Barometric conditions producing continental temperatures prevailed on 10 days, during which time the mean temperature averaged 34 deg.; oceanic temperatures prevailed on five days, with a mean temperature of 44 deg., and dynamic temperatures prevailed on 13 days, during which time the mean temperature was 42 deg. The oceanic temperature is higher than the dynamic, for the reason that the

mean temperatures of the 5th, 6th and 7th, averaging 25 deg., were necessarily included in the dynamic dates. These temperatures followed the cold period produced by continental causes, but they show the commencement of the dynamic effects; excepting the mean temperatures of the 5th, 6th and 7th from the dynamic data, the latter then has a mean of 47 deg., or 3 deg. higher than from oceanic causes.

Temperature data of Portland were used to illustrate the effect of these three classes, and what is true at Portland is relatively true over the Pacific Northwest, as is shown by the following statement, which was prepared and used by the writer in 1895, to illustrate dynamic heating, and which is especially appropriate at this point of the discussion. The table gives the pressure and temperature at 8 A. M., 75th meridian time, from November 8 to November 19, 1895, at regular weather bureau stations in Oregon and Washington, and in addition those recorded at Helena, Mont., and at Idaho Falls, Idaho.

Pressure and Temperature.

November, 1895.	Portland.		Roseburg.		Seattle.		Baker City		Spokane.		Helena.		Idaho Falls.	
	Bar.....	Temp.....	Bar.....	Temp.....	Bar.....	Temp.....	Bar.....	Temp.....	Bar.....	Temp.....	Bar.....	Temp.....	Bar.....	Temp.....
8.....	30.36	34	30.34	26	30.36	46	30.32	30	30.42	32	30.30	34	30.46	16
9.....	30.16	34	30.18	32	30.10	42	30.26	26	30.26	32	30.30	28	30.54	10
10.....	30.12	48	30.14	46	30.02	48	30.04	34	30.04	36	30.22	26	30.42	8
11.....	30.36	36	30.30	36	30.32	40	30.22	32	30.32	30	30.28	28	30.36	12
12.....	29.86	36	29.90	38	29.98	40	29.96	20	30.02	24	30.10	24	30.14	24
13.....	30.34	44	30.40	36	30.26	40	30.34	20	30.30	32	30.12	34	30.16	28
14.....	30.40	50	30.48	46	30.28	54	30.38	32	30.32	42	30.32	42	30.50	32
15.....	30.62	56	30.62	52	30.50	56	30.62	32	30.44	50	30.30	54	30.56	36
16.....	30.58	46	30.52	48	30.56	48	30.60	28	30.50	42	30.32	50	30.54	36
17.....	30.32	44	30.30	42	30.26	48	30.38	32	30.18	40	30.08	44	30.46	34
18.....	30.36	44	30.30	42	30.36	50	30.32	30	30.26	38	30.00	50	30.30	32

That the position of the "high" and its flowing to the "low" produced the rise in the temperature, or dynamic heating, in this case, is thought to be fully shown, for, on the morning of November 12, the barometer at Portland was 29.86, the temperature 36 deg.; on the morning of the 15th the barometer was 30.62 and the temperature 56 deg., a rise in pressure of 0.76 of an inch and a rise of 20 deg. in the temperature.

At Roseburg the rise in the barometer was 0.72 of an inch, and the temperature rose 16 deg.; at Seattle the barometer rose 0.72 of an inch, and the temperature 16 deg.; at Baker City the barometer rose 0.66 of an inch, and the temperature 12 deg.; at Spokane the barometer rose 0.42 of an inch, and the temperature 26 deg.; at Helena, the barometer rose 0.20 of an inch, and the temperature 30 deg., and at Idaho Falls, the barometer rose 0.42 of an inch and the temperature 12 deg.

In the last-mentioned case the rise in the temperature was not due to local dynamic heating, but was a result of it in the surrounding sections. Under some circumstances a rise from 0.25 to 0.75 of an inch in pressure will produce colder weather, but under other conditions, such as those which prevailed on this occasion, a rise in pressure will produce a rise in temperature over the Northwest portions of the United States, the rise in temperature in the latter case accompanying a rise in pressure.

A careful analysis of the facts as stated will no doubt convince the reader that too much credit has been given the "Kuro Siwo," and the Mexican gulf current as well, for modifying influences upon the temperature, and that while the Pacific ocean, per se, has a great influence upon the temperature of the Pacific Northwest, yet the high mean temperature of winter is due more to the influence of dynamic heating than to the influences of the ocean.

B. S. PAGUE,
Forecast Official, U. S. Weather Bureau.

Charts are published upon the following pages to illustrate the relative position of the "high" and the "low" pressures necessary to produce, in the most distinct manner, the temperatures described, which the writer has been pleased to name Continental, Dynamic and Oceanic.

That which is called Dynamic temperature in this thesis was in "Weather Forecasting and Weather Types" called by the author, the present writer, the temperature of "Chinook Winds," or, in other words, the temperature of the Chinook winds is produced by dynamic heating, the winds themselves being the result of unequal barometric pressure.

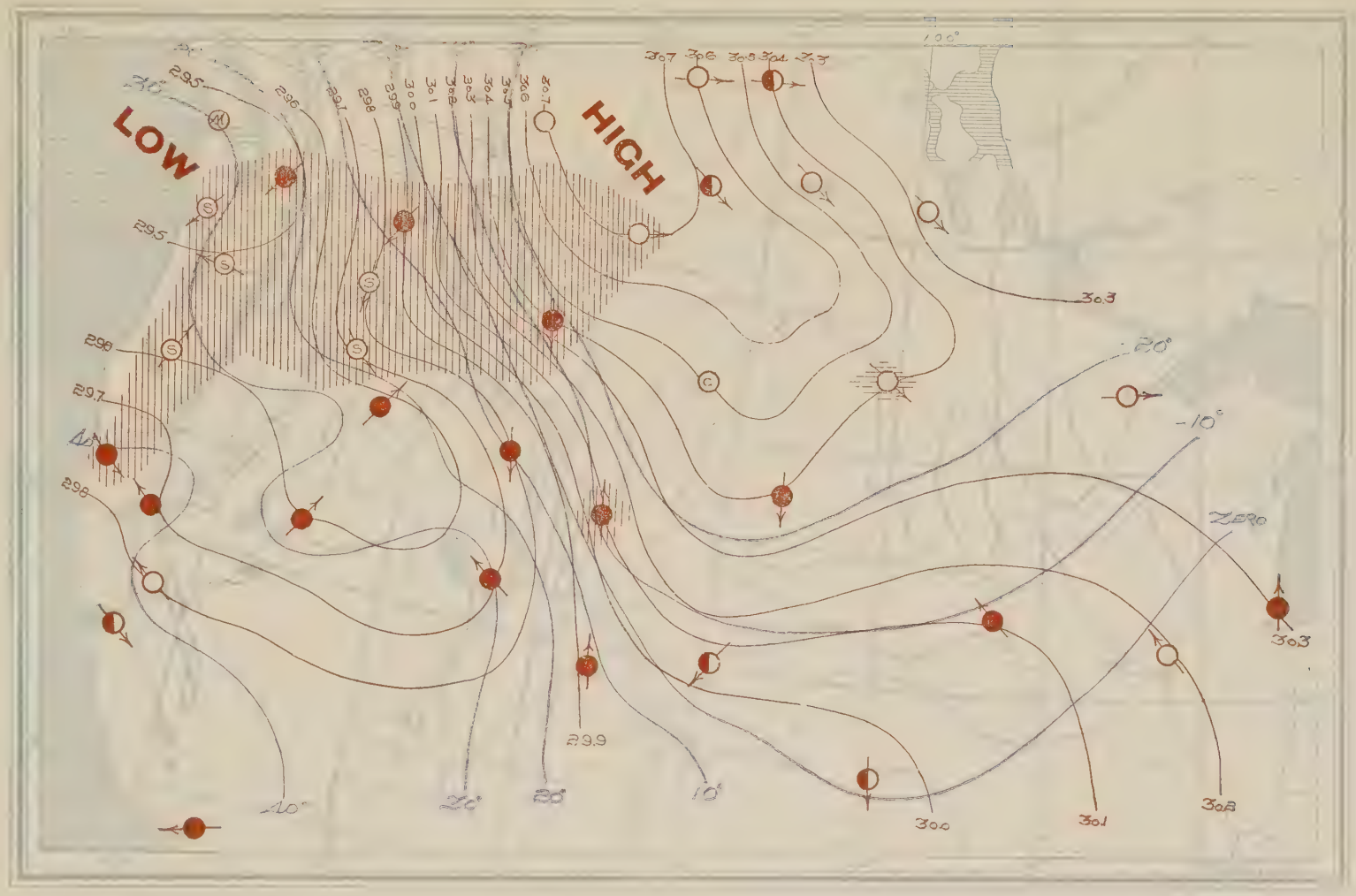
CHART NO. 1.

CONTINENTAL.

The weather conditions prevailing over the northwestern portion of the United States and over the western Canadian provinces at 8 A. M. February 1, 1899, are shown on the chart on the opposite page.

An area of high pressure, 30.74, is central at Calgary, and an area of low pressure, 29.44, is central over western Washington. The movement of the atmosphere being from the "high" to the "low," the cold winds from the north flow south and southwestward, producing low temperatures over the Pacific Northwest. The air in the "high" has temperatures of from 24 to 30 degrees below zero; it reaches the country west of the Rocky mountains greatly modified, due to dynamic heating and the influence of the ocean, so much so that as the lowest levels are reached, especially west of the Cascades, the temperatures are above zero. The temperature of the air, over the Pacific Northwest, is directly influenced by the "high" when it is central as is shown on the chart; such "highs" carry air entirely from the land, hence the name "Continental," assigned to the resulting temperatures.

Chart I.---CONTINENTAL.



Weather Chart, 8 a. m., February 1, 1899.

CHART NO. 2.

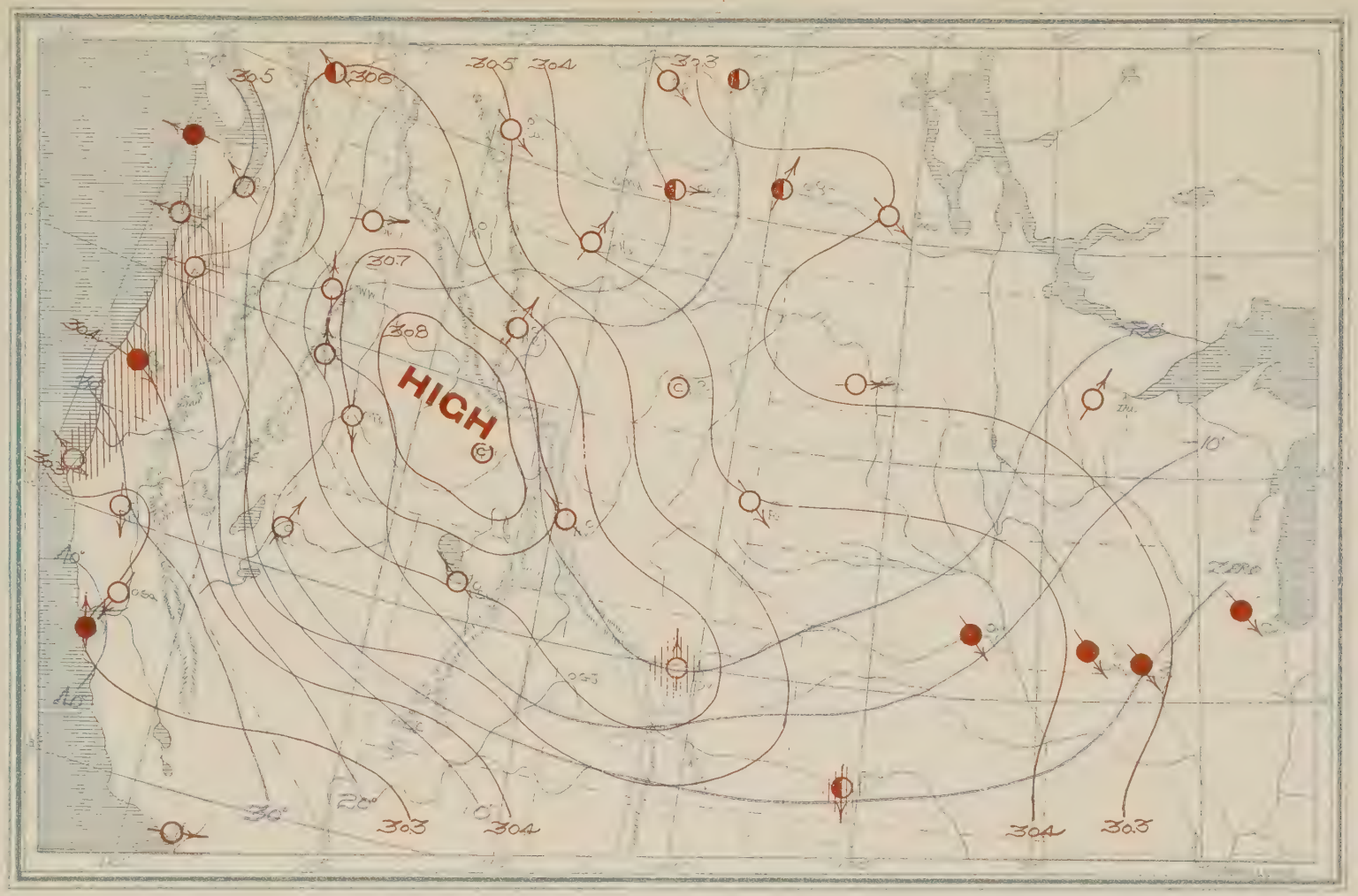
DYNAMIC.

The weather conditions prevailing over the northwestern portion of the United States and over the western Canadian provinces at 8 A. M. February 6, 1899, are shown on the chart on the opposite page.

After the passage of the weather conditions produced by the "high" shown on chart No. 1 an area of high pressure (30.84) became central over the plateau region of southern Idaho and adjacent states. The gradient northwestward to the ocean is distinct, though not as marked as in some instances; on the 9th the gradient was much better defined; it was sufficient, however, on the 6th to start the movement of the air from the high to the lower pressure along the northern coast, and the flow of the air down the mountain side caused it to be heated by compression; hence the name "Dynamic," assigned to it.

Barometric conditions, such as are shown on the chart, upon the opposite page, prevail about twenty per cent. of the time from November 1 to March 1 of each year, and, as these conditions produce mild temperatures, the claim is set up that it is dynamic heating which produces the mild temperature of the Pacific Northwest.

Chart II.---DYNAMIC.



Weather Chart, 8 a. m., February 6, 1899.

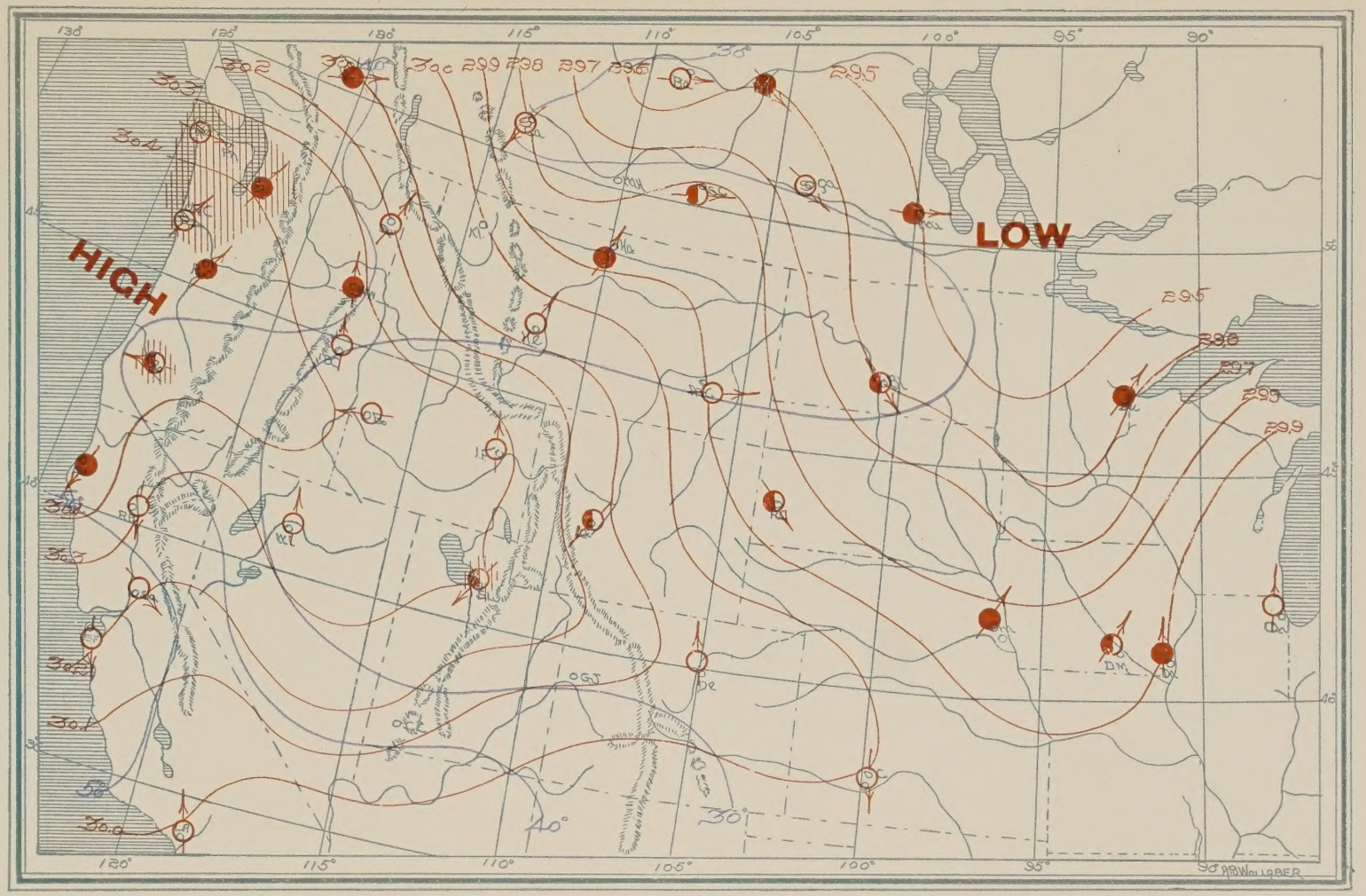
CHART NO. 3.

OCEANIC.

The weather conditions prevailing over the northwestern portion of the United States and over the western Canadian provinces at 8 A. M. February 16, 1899, are shown on the chart on the opposite page.

The chart shows the third type of weather conditions which enter into the discussion of the subject of temperature control over the Pacific Northwest. In February, 1899, continental conditions set in, which were followed by dynamic; the latter ceased on the 10th and began again on the 12th, ending on the 14th, when an area of high pressure (30.42) moved from the ocean to the California coast, thence northward, being central over western Oregon the morning of the 16th; it then moved eastward to southern Idaho, carrying with it the temperature it obtained from the ocean; hence the "high" of this class is termed "Oceanic" and the temperatures resulting are termed "oceanic temperatures."

Chart III.---OCEANIC.



Weather Chart, 8 a. m., February 16, 1899.